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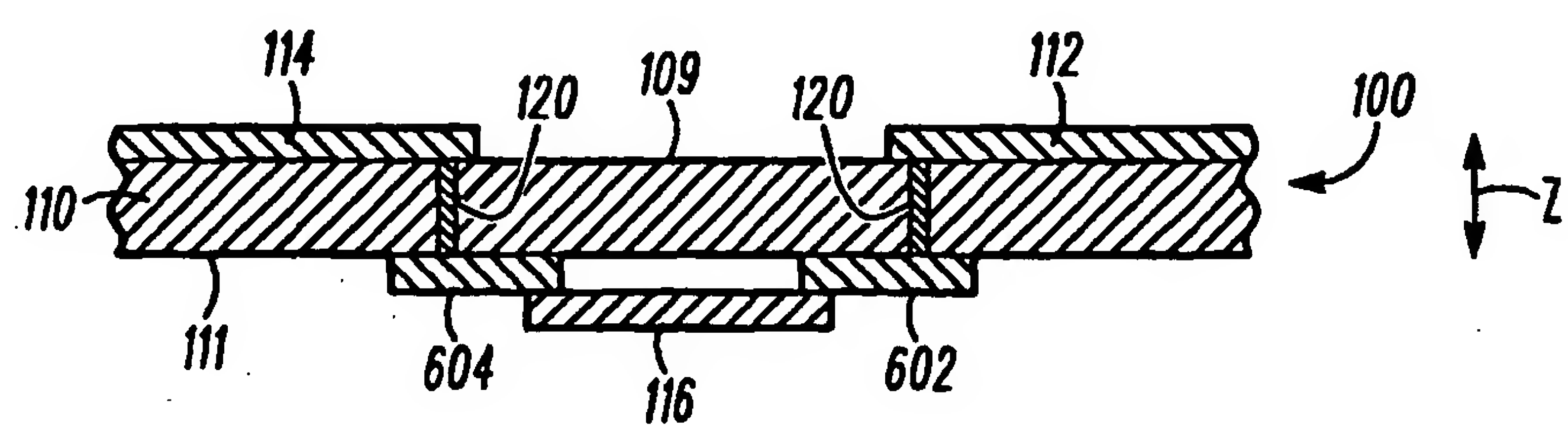
(54) Title: CAPACITIVELY POWERED DATA COMMUNICATION SYSTEM WITH TAG AND CIRCUIT CARRIER APPARATUS FOR USE THEREIN



(57) Abstract: An RFID tag (100) and circuit carrier (130) includes a substrate (110) having a first and a second surface. Disposed on the first surface of the substrate are a first electrode (112) and a second electrode (114). The first and second electrodes are electrically isolated from each other. Disposed on the second surface of the substrate (110) are first and second interconnect pads (602, 604). First and second interconnect pads are electrically isolated from each other. Conductive vias (120) disposed in and transversing the substrate provide electrical connection between the interconnect pads (602, 604) and the electrodes (112, 114). The tag (100) has an RFID circuit (116). First and second interconnect pads (602, 604) are couple to pads (38, 40) on an integrated circuit (116). Adhesive is applied on the pads for securing the circuit (116) to the carrier (130) to complete tag (100).

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Capacitively Powered Data Communication System with Tag and Circuit Carrier Apparatus for Use Therein

Cross Reference to Related Patents

This application is related to U.S. Patent Application Serial Number 09/151,901, filed September 11, 1998, entitled "Radio Frequency Identification Tag Apparatus and Related Method," and assigned to Motorola, Inc.

Technical Field

This invention relates in general to a wireless data communication system and particularly a capacitively powered data communication system. Specifically, the invention relates to a portable device for use within such a system and a structure for use with such a portable device.

Background of the Invention

Remotely powered electronic devices and related systems are known. For example, U.S. Patent No. 5,009,227 issued to Geiszler et al. entitled Proximity Detecting Apparatus, discloses a remotely powered device which uses electromagnetic coupling to derive power from a remote power source and then uses both electromagnetic and capacitve coupling to transmit stored data to a receiver often collocated with the remote power source. Such remotely powered communication systems are commonly known in the field of radio frequency identification ("RFID"). In such systems the remote power source is known as a "Reader, or an exciter," while the remotely powered portable device may be known as an "RFID tag".

Earlier RFID tags and systems primarily use electromagnetic coupling to power the RFID tag and couple the RFID tag with an exciter system and its

associated receiver. The exciter generates an electromagnetic excitation signal used to power up the RFID tag and cause the device to transmit a signal including stored information. The receiver then receives the signal produced by the RFID tag to demodulate and recover the data.

Known electromagnetic coupling mechanisms include an oscillator as part of the exciter and a coil antenna on both the exciter and the RFID tag. The RFID tag typically includes an electronic circuit, such as an integrated circuit and memory. By way of example, in an earlier system, excitation circuitry is connected to a coil antenna, which radiates excitation signals that are picked up by a coil antenna mounted on a tag that contains the electronic circuit. The excitation signals energize the circuit, which then provides an information-carrying signal that is transmitted to the receiver using electromagnetic or capacitive coupling.

One problem with the use of electromagnetic coupling between an RFID tag and either an exciter or a receiver has been the complexity involved in the manufacture of tags that employ a coil antenna. The spiral layout of a typical coil antenna makes the tag more difficult to produce and increases tag cost and size. The coil antennas require tight tolerances for efficient performance. Additionally, typical coil antennas have undesirable thermal compression characteristics that affect, in particular, the ability to create a flat tag or remote device that encompasses the coil.

RFID tags and associated systems have numerous uses. By way of example, RFID tags are frequently used for personal identification in automated gate sentry applications protecting secured buildings or areas. These tags often take the form of access control cards. Information stored on the RFID identifies the person seeking access to the secured building or area. Older automated gate sentry applications require the person accessing the building to insert or swipe their identification tag into or through a reader for the system to read the information from the identification tag. Newer RFID tag systems allow the tag to be read at a distance, thereby eliminating the need to insert or swipe an identification tag into or through a reader. Most typically, the

user simply holds or places the tag near or in proximity to the reader or base station, which is coupled to a security system securing the building or area. The base station transmits an excitation signal to the tag that powers circuitry contained on the tag. The circuitry, in response to the excitation signal, communicates stored information from the tag to the base station, which receives and decodes the information. The information read is used by the security system to determine if access is appropriate. Also, RFID tags may be written remotely by an excitation signal appropriately modulated in a predetermined manner.

In addition to typical applications for access control of persons, RFID tags may be useful in electronic animal identification, baggage tracking, parcel tracking, inventory management applications, asset identification and tracking, personal computer access and security, and other applications involving identification of things. These applications involve transmitting stored information from a tag to an exciter/reader when the tag is brought within the excitation field of the exciter/reader. Also, these applications may involve writing information to a tag. RFID tags for these applications may need to be durable for long-term use or disposable, for temporary use.

In applications for identification of persons and things, bar codes are almost universally employed. Generation of the bar code is very inexpensive. However, one problem associated with bar codes and bar code readers is that the bar codes must be precisely aligned with the bar code reader in order to be read. Another problem with bar codes is that the bar codes may become unreadable as a result of damage, for example, exposure to moisture, or wear and tear from use. RFID tags address some of the shortcomings of bar codes.

In addition to the need to transmit stored information via radio frequency transmission, it is often desirable for an RFID tag to be very thin, very flat, flexible, semi-flexible, or rigid and to nevertheless be compatible with printing technologies, including but not limited to die sublimation printing, ink jet printing, and flexographic printing and the like. Prior RFID tags incorporating coils are limited in their ability to be flat and thin and low in cost. This has

greatly limited their application in the market place, particularly in areas where the cost of the tag must be competitive with a barcode. Therefore, there is a need for a thin, flat, inexpensive, printable RFID tag and associated communication system.

Brief Description of the Drawing

FIG. 1 is a plan view of an RFID tag in accordance with a preferred embodiment of the present invention;

FIG. 2 is a cross-sectional view of a circuit carrier structure for use in association with the RFID tag of FIG. 1;

FIG. 3 is a cross-sectional view of the RFID tag taken along line 3-3;

FIG. 4 is a partial plan view of the RFID tag of FIG 1;

FIG. 5 is a functional block diagram illustrating a first embodiment of a capacitively powered data communication system in accordance with the present invention;

FIG. 6 is a circuit block diagram illustrating an alternative embodiment of the reader and receiver of FIG. 5, shown functionally sharing a single electrode;

FIG. 7 is a circuit block diagram illustrating a second implementation of the reader and receiver of FIG. 5, shown functionally sharing an electrode pair;

FIG. 8 is a cross-sectional view of an alternative embodiment of an RFID tag in accordance with the present invention;

FIG. 9 is a cross-sectional view of yet another embodiment of an RFID tag in accordance with the present invention; and

FIG. 10 is a cross-sectional view of still another embodiment of an RFID tag in accordance with the present invention.

Detailed Description of the Preferred Embodiment

While the specification concludes with claims defining the features of the invention that are regarded as novel, it is believed that the invention will be better understood from a consideration of the following description in conjunction with the drawing figures, in which like reference numerals are carried forward.

Briefly, a capacitively powered RFID tag includes a substrate member having a first and second surface. Disposed on the first surface of the substrate are a first electrode and a second electrode. The first and second electrodes are electrically isolated from each other and are electrically coupled to two separate pads or interconnects disposed on an integrated circuit. Such pads are best seen with reference to FIGS. 8-10 and identified as elements 38 and 40. Additional information regarding such interconnection pads may be found in U.S. Patent Application Serial Number 09/393,097, filed September 9, 1999, entitled "Radio Frequency Identification Tag Circuit Chip Having Printed Interconnection Pads," assigned to Motorola, Inc. and incorporated herein by reference.

In one embodiment, conductive vias in the substrate are used to couple the electrode pair to the pads on the integrated circuit. The integrated circuit includes a power circuit that produces a supply voltage for electronics on the integrated circuit in response to voltages coupled over the air to the pads on the integrated circuit via the first and second electrodes. In the preferred embodiment, first and second interconnect pads are printed or otherwise disposed on the second surface of the substrate. Adhesive is applied on at least a portion of the second surface of the substrate and the first and second interconnect pads for securing the integrated circuit to the tag. The first and

second interconnect pads are electrically connected to the first and second electrode pair through conductive vias 120 as seen with reference to FIGS. 1-3 or an aperture 31 in the substrate, as seen with reference to FIGS 9 and 10.

As discussed herein, a wide variety of non-conductive materials are used for the substrate. Likewise, a wide variety of conductive materials are used for the first and second electrodes and interconnect pads. The RFID tag is preferably programmed with information or may receive data from a reader/exciter for later storage in memory. The RFID tag has a myriad of uses in applications for identifying persons, places, or things.

FIG. 1 shows the RFID tag 100 in accordance with the present invention. Tag 100 has a substrate 110, a first electrode 112, a second electrode 114 and an integrated circuit 116 (not shown). Substrate 110 provides a base for holding the components of tag 100. Formed on the surface 109 of substrate 110 are the electrode elements 112 and 114. The first and second electrodes 112, 114 are electrically isolated from each other. Integrated circuit 116 (not shown) contains the electronics associated with tag 100 and is coupled to first electrode 112 and second electrode 114 by conductive vias 120 shown in dashed lines.

FIG. 2 is a cross-sectional view of a circuit carrier 130 for use in the tag 100 of the capacitively powered data communication system of the present invention. The first surface 109 of the circuit carrier 130 is formed by the front surface of the substrate 110. The first surface has first and second electrodes 112, 114 disposed thereon. The second surface 111 of the circuit carrier 130 is formed by the back surface of the substrate 110. The second surface has first and second interconnect pads 602, 604 disposed thereon. Electrodes 112, 114 are electrically isolated one from the other. Likewise interconnect pads 602, 604 are electrically isolated. Conductive vias 120 are disposed in and transverses the substrate 110 to provide electrical connection between interconnect pad 602 and electrode 112, as well, as between interconnect pad 604 and electrode 114.

FIG. 3 is a cross-sectional view of tag 100 taken along line 3-3 of FIG.1. As best seen in FIG. 3, first and second electrodes112, 114 are disposed on the surface 109 of substrate member 110. Integrated circuit 116 is coupled to first and second interconnect pads 602 and 604 via adhesive or other well-known methods of bonding or adhering. Information regarding some but not all alternative methods of bonding may be found with reference to U.S. Patent Application Serial Number 09/393,097 as mentioned above, as well as U.S. Patent Application Serial Number 09/115,279, filed July 14, 1998, and entitled "Radio Frequency Identification Tag Having Printed Circuit Interconnections," and U.S. Patent Number 6,018,299 issued January 25, 2000, both assigned to Motorola, Inc. Based upon foregoing, it will be appreciated by those skilled in the art that integrated circuit 116 may be direct or flip-chip bonded to interconnect pads 602, 604 in accordance with the present invention.

Regarding bonding by adhesive, it will be appreciated by those skilled in the art that the adhesive may be applied by any known or available method of application and may therefore be applied in a continuous layer, in drops, or as a film, including but not limited to applications by hand or by machine. The tag 100 and circuit carrier 130 shown in FIGS. 1-3 have a generally rectangular configuration. However, the shape and configuration of tag 100 may vary depending upon the application. Also, the thickness of tag 100 varies and is only limited by the thickness of substrate 110, first and second electrodes 112, 114, integrated circuit 116, and first and second interconnect pads 602 and 604.

Substrate 110 provides the base for tag 100. Substrate 110 is composed of any non-conductive component. Suitable materials for substrate 110 include but are not limited to paper, acetate, polyester, polyethylene, polypropylene, polypropylene with calcium carbonate, polyvinyl chloride, acrylonitrile butadiene styrene (ABS), plastic, wood, glass, textiles, ceramics or other organic and inorganic non-conductive materials. The selection of material for substrate 110 will vary depending upon the application. For example, in an application wherein tag 100 is disposable, substrate 110 is preferably paper. For an application where tag 100 is durable and reusable, for

example as an access control card, substrate 110 is preferably plastic, polyvinyl chloride or polyester. In an application where the tag is to be integrated into an article of manufacture, the substrate can be any non-conductive or substantially non-conductive material and the tag will operate, so long as sufficient electrical isolation is maintained between the first and second electrode pair and the first and second interconnect pads, respectively.

Substrate 110 may alternatively be formed from a web of material or from discrete portions of a material. The preferred form of material used for substrate 110 varies depending on the application for tag 100 and the process used to manufacture tag 100. For example, for manufacture of tag 100 using a web printing process, substrate 110 is preferably formed from a rolled web of paper or other material. Alternatively, for example, substrate 110 may be formed from a fan-folded web of paper or other material.

First and second electrodes 112, 114 and first and second interconnected pads 602, 604 are formed from numerous suitable conductive materials. The conductivity of electrodes 112, 114 and pads 602, 604 may vary considerably with little or no performance degradation. For example, electrodes 112, 114 with conductivity from 0 ohms per square to 500 K-ohms per square are operable for read-only applications. Electrodes 112, 114 with conductivity from 0 to 100 ohms are operable for read/write applications. Suitable materials for electrodes 112, 114 and pads 602, 604 include conductive inks, semi-conductive materials, or metallic materials like wire or metal foil. More specifically, suitable materials for electrode elements 112, 114 and pads 602, 604 include copper, graphite, metalized polyester, aluminum, silver, gold, metalized ink or graphite and carbon doped inks. Electrode elements 112, 114 and pads 602, 604 are formed on substrate 110 using any suitable process including printing, lamination, adhesively securing, and deposition. The shape of electrodes 112, 114 is not limited, but preferably, for optimal performance, antenna elements 112, 114 consume substantially all of the available surface area 109 of substrate 110.

Interconnection pads 602, 604 are typically smaller than electrodes 112, 114 and serve the primary purpose of coupling the circuit 116 to electrode elements 112, 114 through conductive vias 120. As will be appreciated by those skilled in the art, the tag of FIGS. 1-3 separates the circuit 116 from the electrode elements 112, 114. In accordance, the substrate 110 provides that physical separation and a layer of added protection. This is especially true when the substrate is the outer surface or side wall of: an article of manufacture such as, but not limited to, a pager, a cell phone, a personal computer, consumer electronics devices, home appliances, and the like; or an article of packaging such as, but not limited to a box, a crate, a case, a bag, an envelope, plastic wrap, and the like.

The impedance characteristics of electrodes 112, 114 are preferably varied by the type of materials selected and by the dimensions and concentrations of the selected materials. For example, where conductive ink is used for electrodes 112, 114, multiple applications of the conductive ink may be used to vary the impedance characteristics thereof. Unlike predecessor RFID tags that relied on electromagnetic coupling, electrode elements 112, 114 are not coils.

Integrated circuit 116 houses the circuitry for powering up the RFID tag and sending a stored signal or information in response to receipt of an electrostatic exciter signal. For some applications, integrated circuit 116 includes the circuitry to write new information into the tag in response to receipt of an excitation signal from the exciter. The functions of integrated circuit 116 are discussed further below with respect to FIG. 5.

Adhesive may be used to secure the integrated circuit 116 to the tag 100. Suitable adhesive materials include non-conductive and conductive adhesives. Preferably, adhesive is a non-conductive transfer adhesive film. The adhesive may be applied in any manner including covering the entire available surface area of the tag and associated components or covering only certain components of the tag. However, if an isotropic adhesive (conductive in all directions) is used, the adhesive must be applied in a manner that does

not provide a conductive path between first and second electrodes 112, 114 or first and second interconnect pads 602, 604.

Alternatively, the integrated circuit 116 may be coupled to the first and second interconnect pads 602, 604 by any suitable manner that allows an electrical connection between the integrated circuit 116 and the pads 602, 604 yet isolates pads 602, 604 from each other. A preferred method for coupling integrated circuit 116 to pads 602, 604 is a conductive anisotropic adhesive that conducts in the "Z" direction, as shown in FIG. 3. Alternatively, an isotropic adhesive may be used so long as the isotropic adhesive used to couple first pad 602 to the integrated circuit 116 is isolated from the isotropic adhesive used to couple the second pad 604 to the integrated circuit 116.

The embodiments of the invention shown in FIGS. 1-3 form relatively flat and thin RFID tags and tag circuit carriers. These tags are adapted to be formed by a number of printing processes including die-sublimation printing, ink jet printing, flexographic printing, web printing, screen printing, pad transfer printing, and any of those other printing processes either now known or as may be later developed.

The embodiments of the invention shown in FIGS. 1-3 may have some irregularity in the outer surface due to the thickness of integrated circuit 116, which does not extend across the entire surface area of the tag. This irregularity is of little consequence when the circuit 116 is disposed on the inner surface of the outer sidewall of an article of manufacture, an article of packaging, or the like.

FIG. 4 is a partial plan view of the second side 111 of tag 100 showing first and second interconnecting pads 602, 604. Disposed on and coupled to the first and second pads 602, 604, is integrated circuit 116. As best seen in FIG. 3, integrated circuit 116 is secured to the first and second pads 602, 604, which in turn are coupled to the first and second electrodes 112, 114, by conductive vias 120. This facilitates an electrical connection between integrated circuit 116 and first and second electrodes112, 114. Integrated

circuit 116 is secured or bonded to pads 602, 604, using an adhesive or any bonding technique, including the adhesives mentioned above. The bonds 34 and 36 are best seen with reference to FIGS. 8-10.

FIG. 5 is a block diagram illustrating a system 800 including an exciter 802, reader 804 and integrated circuit 116. Exciter 802 is coupled to a first antenna element 806 and a second antenna element 808. Reader 804 is coupled to an antenna element 810. Integrated circuit 116 is coupled to a first electrode 112 and a second electrode 114. Exciter 802 generates a signal that is capacitively coupled to integrated circuit 116 from antenna elements 806, 808 to electrodes 112, 114. The signal generated by exciter 802 may include information that is to be written to integrated circuit 116. In response to the signal from exciter 802, circuit 116 powers the electronics, writes the appropriate information and generates a read signal that is capacitively coupled over the air to reader 804 via antenna element 810. Reader 804 reads the signal to decode the information for use by other systems (not shown).

Integrated circuit 116 includes a rectifier and power circuit 814, a write decoder 816, a controller 818, a memory 820, a modulator 822 and a clock extraction circuit 824. Rectifier and power circuit 814 is coupled to electrodes 112, 114 to receive the signal from exciter 802. This alternating current (AC) signal is rectified by rectifier and power circuit 814 to produce a direct current (DC) signal that is then regulated to provide a power supply voltage V+ for integrated circuit 116. The AC signal from exciter 802 is passed to write decoder 816. Write decoder 816 decodes the information modulated into the signal by exciter 802 to determine the appropriate action to be taken by integrated circuit 116. Write decoder 816 is coupled to controller 818. Write decoder 816 decodes the signal from exciter 802 into a write command. Controller 818 controls a memory 820 that is written to in response to an appropriate signal or write command from exciter 802 and/or read from in response to an appropriate signal from exciter 802. Memory 820 stores digital information. Information read from memory 820 is modulated by modulator 822, which provides a signal that is capacitively coupled through at least one of

antenna elements 112, 114 to reader 804. Clock extraction circuit 824 creates a clock signal for integrated circuit 116 based on the AC signal received from the exciter 802.

Integrated circuit 116 shown in FIG. 5 is a circuit for use in a RFID tag that can be read and written. A preferred RFID circuit that can be read and written has in the past been available from Temic North America, Inc., Basking Ridge, New Jersey. For an integrated circuit that is read only, write decoder 816 need not be included for determining write instructions. A preferred integrated circuit 116 for use in a read only RFID tag has in the past been available from Motorola Indala Corporation, 3041 Orchard Parkway, San Jose, California 95134.

FIG. 6 illustrates a circuit block diagram for a monopole-configured exciter/reader 802, 804 having a single electrode 806. In accordance therewith, a switched resonant transmitter circuit 904, including a resonant tank comprised of coil 134, capacitor 1034, and switch 1030 are shown coupled between source (Vcc) and ground. The switched resonant transmitter circuit 904 is coupled to the electrode 806 for transmission of excitation signals. By shielding coil 134 or employing a pot core or toroid device as a substitute, it will be appreciated by those skilled in the art that the electromagnetic field of coil 134 may be suppressed, such that the reader 804 will operate primarily as an electric field or capacitive reader. Reader/receiver 804 is coupled to the electrode 806 and the node 1312 for receiving electric field signals from a portable device such as an RFID tag 100 as disclosed herein. In this manner both the exciter 802 and reader 804 use the electrode 806. The design of the present embodiment reduces the number of electrodes required for operation. However, since the transmit energy and signals are fed directly into the receiver 804, a greater amount of filtration is required around the expected data carrier for receiving signals in an RFID system having a data carrier of 62.5 kHz and a power carrier of 125 kHz.. Receiver 804 therefore includes filter 1330 to provide the necessary filtration and amplifier 324 is provided to amplify the signal after filtering.

FIG. 7 illustrates a dipole active transmitter 802 combined with receiver 804. Transmitter 802 includes driver 1101, transformer 1001 with coil 134 on the primary and coil 1012 on the secondary. Capacitor 1014 is provided for resonance and electrostatic electrodes 806 and 808 are respectively coupled to nodes 1333 and 1334. Receiver 804 taps off the transmitter at node 1334 although it could tap off node 1333 in the alternative. Because the voltage levels are high on nodes 1333 and 1334, it is expected that a voltage reduction circuit, such as a resistor divider, may be part of the front end filtering at filter 1330 in receiver 804.

Further reference to FIG. 7 illustrates a portable device 100 in proximity to the electrostatic electrodes 806 and 810. As shown in dashed lines, the electrode 808 of the reader/exciter and the electrode 114 of portable device 100 are coupled to a common reference. As shown, the common reference is ground. In accordance therewith, this alternate configuration depicts dipole operation between the reader/exciter 802, 804 and the portable device 100.

RFID tags in accordance with the present invention are useful for numerous applications, including for personal identification in automated gate sentry applications, amusement parks, sporting events, concerts, cruises, ski resorts, vacation resorts and other ticketing and badge applications involving personal identification or entitlement. In addition, RFID tags in accordance with the present invention are useful for article identification for asset tracking, inventory management, labels, animal identification, baggage tracking, parcel tracking and other applications involving the integration of the tags into the article of manufacture or an article of packaging for identification of things or storing information associated with things.

In contrast to prior RFID tags, tags designed in accordance with the present invention are substantially less expensive due to elimination of an inductive coil, a resonant capacitor, a printed circuit board, and a lead frame. Also, RFID tags in accordance with the present invention are flat and thin, may be flexible, semi-flexible, or rigid, and are suitable for printing by standard printing processes.

RFID tags in accordance with the present invention have certain advantages over bar codes and bar code readers, which have traditionally been used for identification of persons and things. In particular, since the stored information in an RFID tag is stored in an integrated circuit rather than in indicia printed on the tag, the stored information is not subject to corruption or destruction by wear and tear on the tag. In addition, the incorporation of a readable and writeable integrated circuit in an RFID tag in accordance with the present invention advantageously allows information associated with a person or thing to be readily updated. Bar codes are limited in this aspect.

Typical applications using RFID tags in accordance with the present invention require that the tag be programmed and printed. For some applications, the tags are completely preprogrammed. For other applications, the tag are programmed just prior to use in order to incorporate certain information unique or related to the person or thing that will be associated with the tag. Therefore, it is desirable to be able to print and program a tag without resort to complex manufacturing processes. The flat, printable tags in accordance with the present invention are easily programmed and printed for a particular application.

For example, a tag in accordance with the present invention is useful as an admissions ticket or pass for a ski resort, amusement park, sporting event, concert or other event. In such applications, it is desirable to have some information preprogrammed into a tag, for example, identification of the event and possibly an identification number associated with the tag. The tag preferably has on a surface the same preprogrammed information indicated by printed or other visual indicia. Prior to use of the tag by an individual, the tag is programmed with information relating to the individual. For example, the tag is programmed with the individual's name, address, social security number, credit card number, or other information related to the individual. After programming, the tag is preferably read to verify that the intended programmed information is stored properly. If the tag is properly programmed, the tag is then printed or

otherwise has indicia placed on the tag. Preferably the indicia placed on the tag coincides with the information stored in the tag.

Applications using tags for the identification of things are similarly programmed and printed with certain information related to the things to be identified. For example, in an inventory tracking application, the tag is programmed with information identifying the type of article, model number and information associated with its manufacture, such as a manufacturing lot and manufacturing location. The tag is preferably also printed with indicia indicating the same information.

Also, in particular where the tag can be read and written, the tag may be deployed in an ISO standard card and used as a cash, credit, or debit card that stores a cash value, credit value or entitlement indication, which is incremented or decremented as the tag is used. Loyalty points based on usage may alternatively be stored in tag memory.

Whereas the present invention has been described with respect to specific embodiments thereof, it will be understood that various changes and modifications will be suggested to one skilled in the art and it is intended that the invention encompass such changes and modifications as fall within the scope of the appended claims. By way of example, the exciter 802 and reader 804 may be integrated into a single device that uses common antenna elements. Moreover, for monopole operation as described in association with FIG.7, it will be appreciated by those skilled in the art that a common reference other than ground may be used. In addition, a node other than an electrode can be used as the point of reference between the reader/exciter 802, 804 and portable device 100 in order to achieve monopole operation.

Regarding the tag 100, while the preferred embodiment employs conductive vias 120 to provide electrical connection between pads 602, 604 and electrodes 112, 114, it will be appreciated that by those skilled in the art, with reference to FIGS 8-10, that alternate techniques and/or methods may be substituted therefore in order to provide this connection without departing from

the spirit or intent of the present invention; namely, an RFID tag or circuit carrier having a non-conductive substrate with conductive electrodes or antenna disposed on a first surface thereof, and interconnect pads disposed on a second surface thereof, the interconnect pads being electrically isolated one from the other, the electrode pair being isolated one from the other, with an interconnect pad being electrically connected to an electrode, the interconnect pads and the electrodes being on opposite surfaces of the non-conductive substrate.

What is claimed is:

1. A radio frequency identification (RFID) circuit carrier comprising:

a non-conductive substrate having a first and second surface;

a first conductive pattern disposed on the first surface; and

a second conductive pattern disposed on the second surface and forming a circuit interconnect, the first conductive pattern and the second conductive pattern being electrically connected.

2. The circuit carrier of claim 1 wherein the first conductive pattern forms an electrode pair.

3. The circuit carrier of claim 1 wherein the first conductive pattern forms an antenna pair.

4. The circuit carrier of claim 1 wherein the first and second conductive patterns are printed on the non-conductive substrate.

5. The circuit carrier of claim 1 wherein the non-conductive substrate is selected from the group of materials consisting of: paper, glass, wood, leather, organic textiles, inorganic textiles, acetate, polyester, polyamides, calcium carbonate, plastic, ceramic, polyvinyl chloride, polypropylene, polyethylene, and non-conductive materials.

6. The circuit carrier of claim 1 wherein the first and second conductive patterns comprise at least one of: ink, metal, carbon, graphite, conductive, and semi-conductive materials.

7. The circuit carrier of claim 1 adapted for use in a radio frequency identification tag.

8. The circuit carrier of claim 1 adapted for use in an article of manufacture.

9. The circuit carrier of claim 1 adapted for use in an article of packaging.

10. The circuit carrier of claim 1 adapted for use in a capacitively powered data communication system.

11. The circuit carrier of claim 1 adapted for use with an article of paper.

12. A radio frequency identification (RFID) tag comprising:

a non-conductive substrate having a first and a second surface;

a first conductive pattern disposed on the first surface and forming an electrode ;

a second conductive pattern disposed on the second surface and forming a circuit interconnect; and

a circuit, electrically coupled to the second conductive pattern, the first and second conductive patterns being electrically connected.

13. The RFID tag of claim 12 wherein the first and second conductive patterns are printed on the non-conductive substrate.

14. The RFID tag of claim 12 wherein the first conductive pattern forms an electrode pair.

15. The RFID tag of claim 14 wherein the electrode pair are electrically isolated one from the other.

16. The RFID tag of claim 12 wherein the circuit interconnect comprises first and second interconnect pads.

17. The RFID tag of claim 16 wherein the first and second interconnect pads are electrically isolated one from the other.

18. The RFID tag of claim 12 wherein the first and second conductive patterns comprise at least one of metal, metal compounds, ink, carbon, graphite, conductive, and semi-conductive materials.

19. The RFID tag of claim 12 wherein the circuit comprises at least one of, discrete components, printed circuit components, and an integrated circuit.

20. The RFID tag of claim 12 for use in a capacitively powered data communication system.

21. The RFID tag of claim 12 disposed in an article of manufacture.

22. The RFID tag of claim 12 disposed in an article of packaging.

23. The RFID tag of claim 12 disposed in an article of paper.

24. The RFID tag of claim 12 wherein the non-conductive substrate comprises at least one of organic and inorganic materials.

25. The RFID tag of claim 12 wherein the non-conductive substrate is comprised of materials selected from the group consisting of flexible, semi-flexible, and non-flexible materials.

26. The RFID tag of claim 12 wherein the first and second conductive patterns are electrically connected by vias in the substrate.

27. The RFID tag of claim 12 further comprising means for connecting the first and second conductive patterns.

28. A capacitively powered data communication system comprising:

a source device comprising:

a transmitter for generating an excitation signal;

a receiver for receiving a data signal; and

first and second electrodes, coupled to the transmitter and the receiver, for transmitting the excitation signal to a portable device and receiving the data signal from the portable device in response to receipt of the excitation signal; and

the portable device comprising:

a non-conductive substrate having a first and second surface;

a first conductive pattern disposed on the first surface of the substrate forming an electrode pair;

a second conductive pattern disposed on the second surface of the substrate forming first and second interconnect pads;

a circuit connected to the first and second interconnect pads; and

connection means for connecting the first electrode to the first interconnect pad and the second electrode to the second interconnect pad,

wherein the portable device is coupled to the source by an interface formed between at least one electrode of the portable device and at

least one electrode of the source when the portable device is in receipt of the excitation signal.

29. The capacitively powered data communication system of claim 28 wherein the portable device is at least one of:

an RFID tag;
an article of packaging
an article of manufacture;
an event ticket;
a label;
an identification badge; and
a debit or credit card.

30. The capacitively powered data communication system of claim 28 wherein the interface is an over the air interface.

31. The capacitively powered data communication system of claim 28 wherein the interface is an electric field interface.

32. The capacitively powered data communication system of claim 28 wherein the interface couples at least one electrode of the portable device to at least one electrode of the source by a reactance predominated by capacitance.

33. A circuit carrier comprising:

a non-conductive substrate having a first and second surface;

a first conductive pattern formed on the first and second surface and forming a first electrode on the first surface and a first interconnect pad on the second surface; and

a second conductive pattern formed on the first and second surface and forming a second electrode on the first surface and a second interconnect pad on the second surface,

wherein the first and second conductive patterns are electrically isolated.

34. An RID tag comprising:

a non-conductive substrate having a first and second surface;

a first conductive pattern disposed on the first and second surface of the substrate and forming a first electrode on the first surface and a first interconnect pad on the second surface;

a second conductive pattern disposed on the first and second surface of the substrate and forming a second electrode on the first surface and a second interconnect pad on the second surface; and

a circuit, electrically coupled to the first and second interconnect pads, the first and second conductive patterns being electrically isolated one from the other.

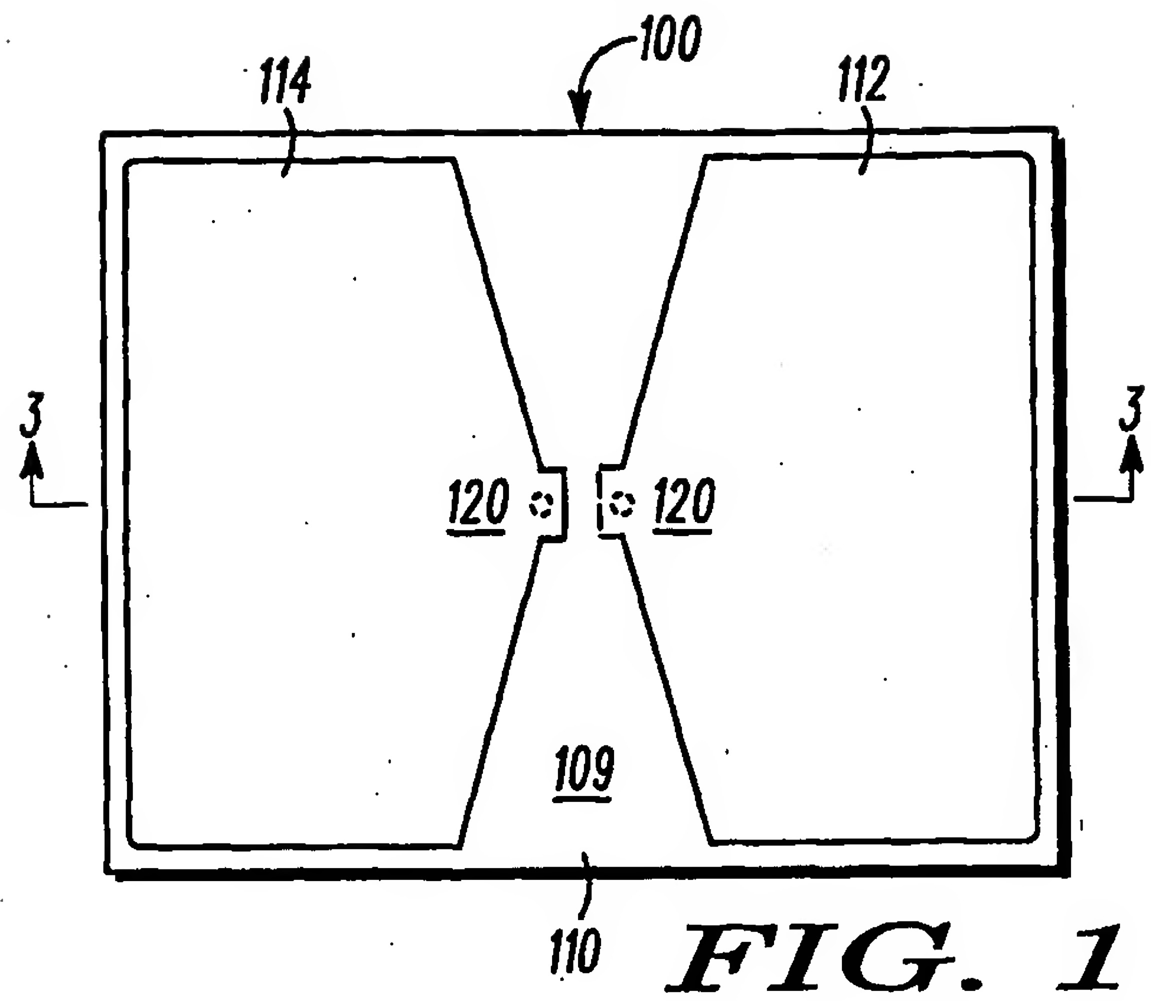


FIG. 1

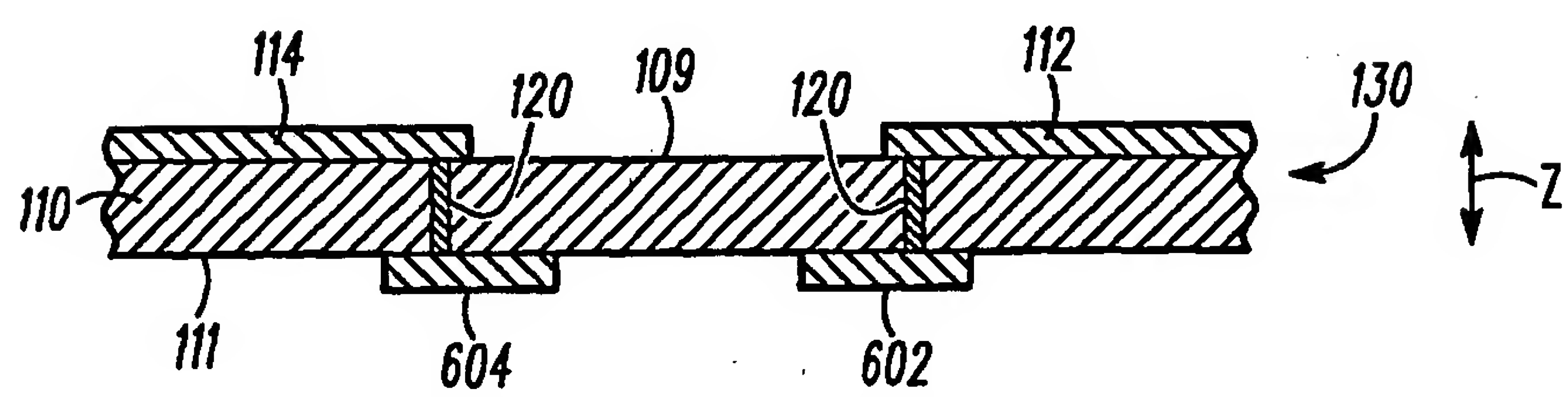


FIG. 2

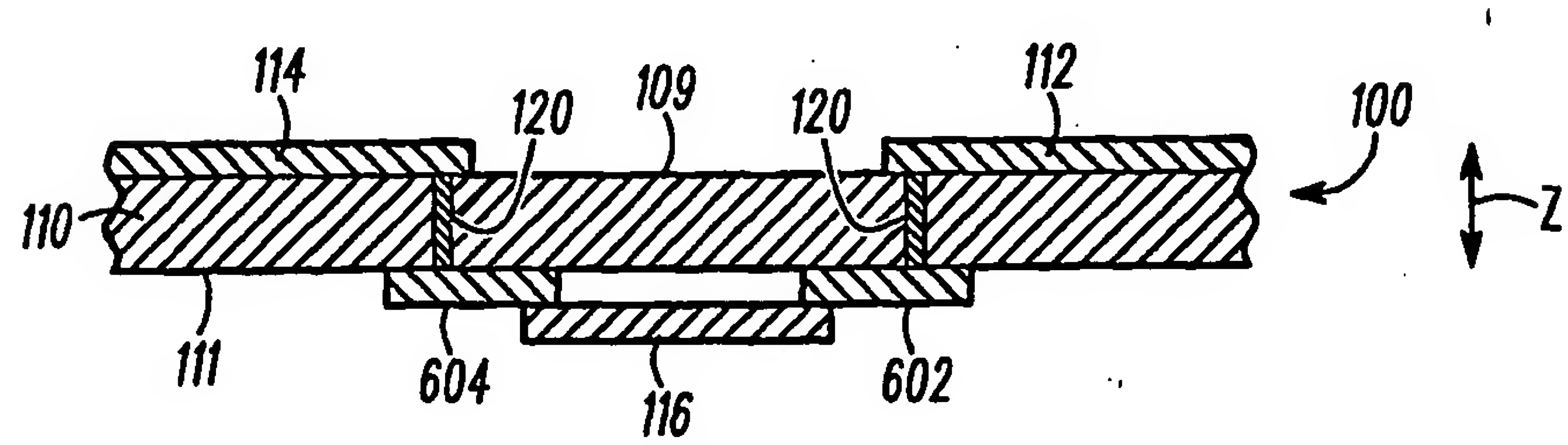


FIG. 3

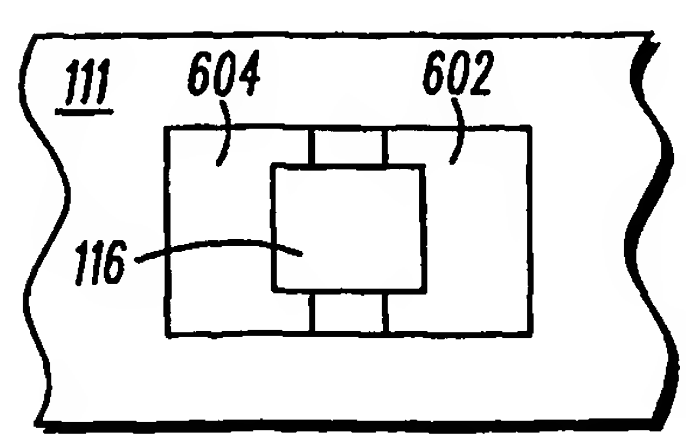
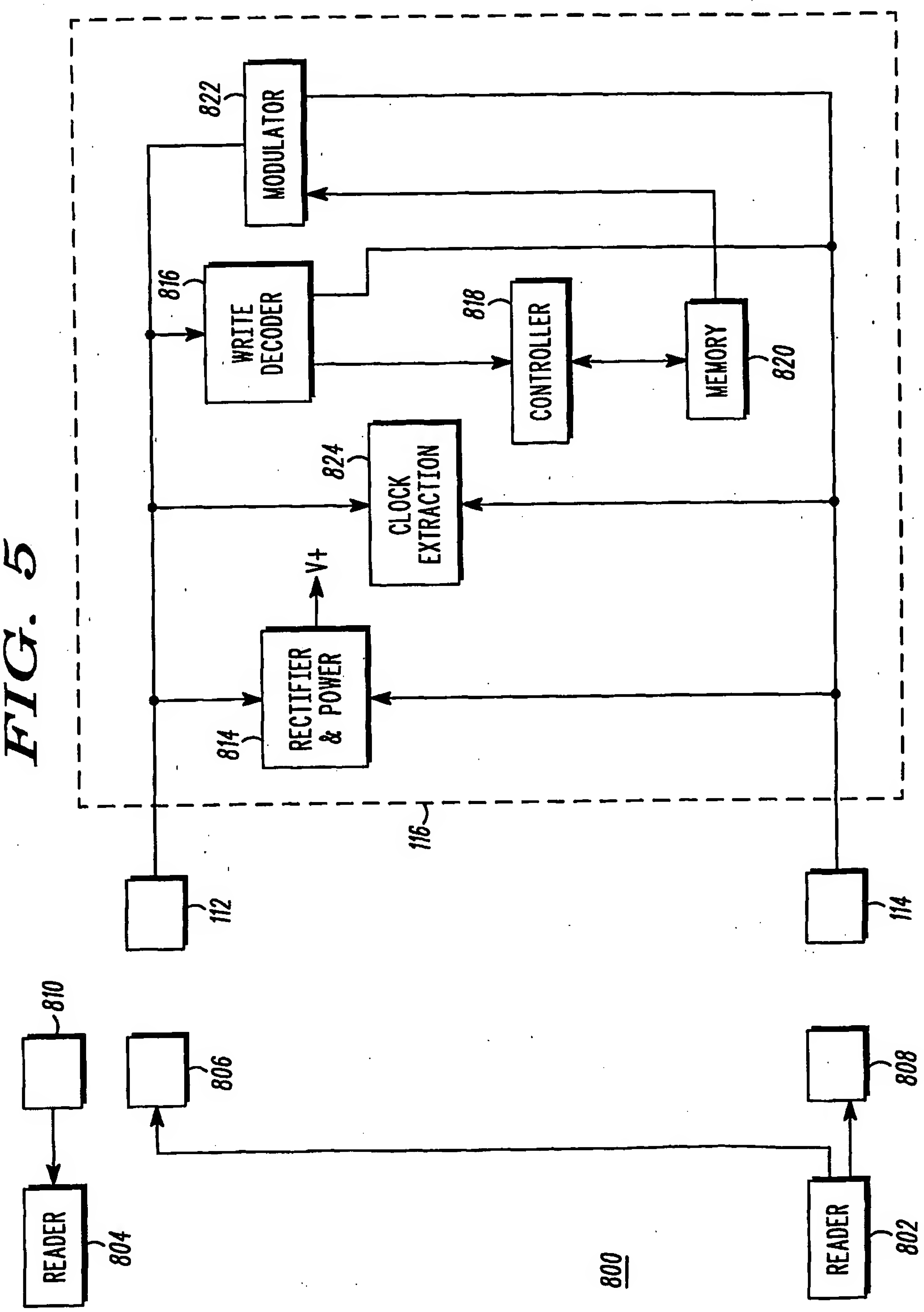


FIG. 4

FIG. 5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WRITE DECODER
816
CONTROLLER
818
MEMORY
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CLOCK EXTRACTION
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112
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810
806
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READER
804
READER
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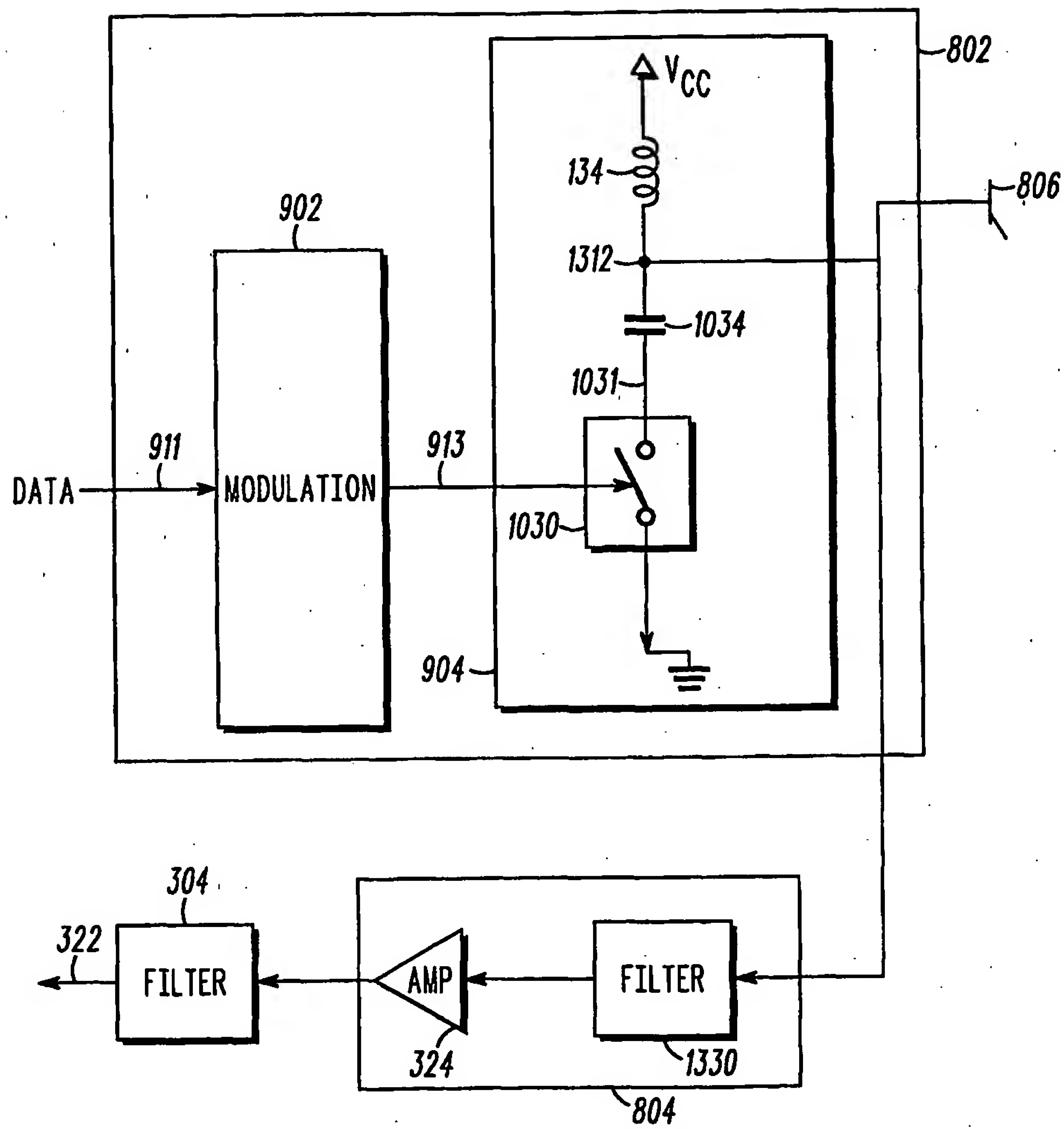
800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902
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911
913
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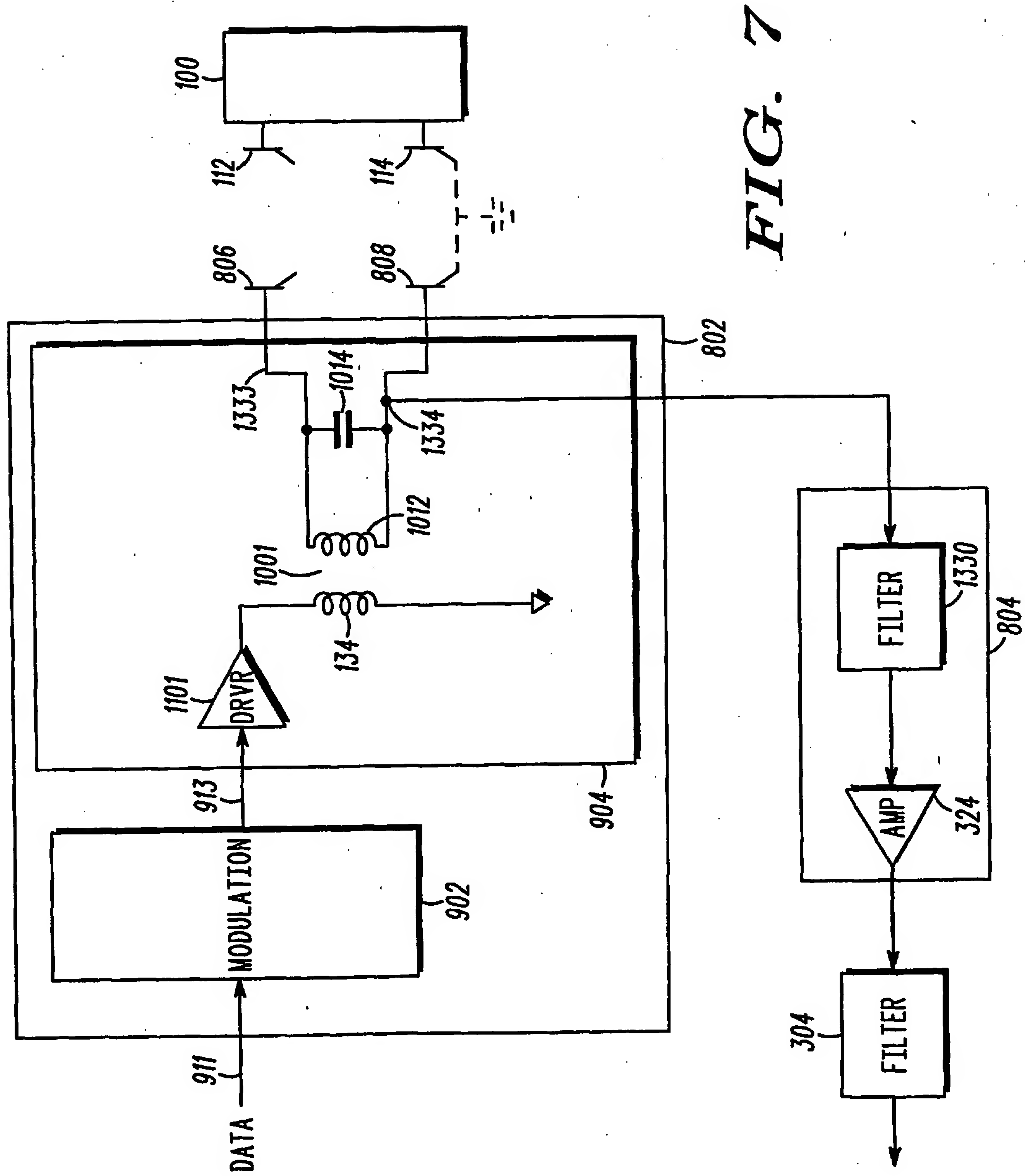
322
FILTER
AMP
FILTER
324
1330
804

FIG. 6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FILTER
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FIG. 7

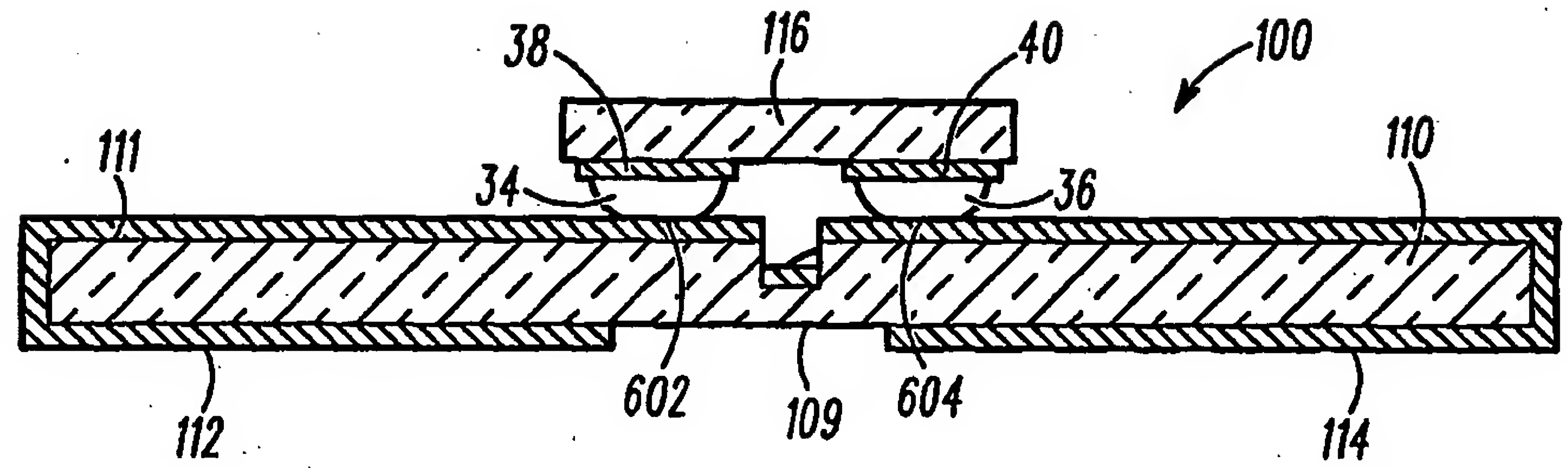

FIG. 8

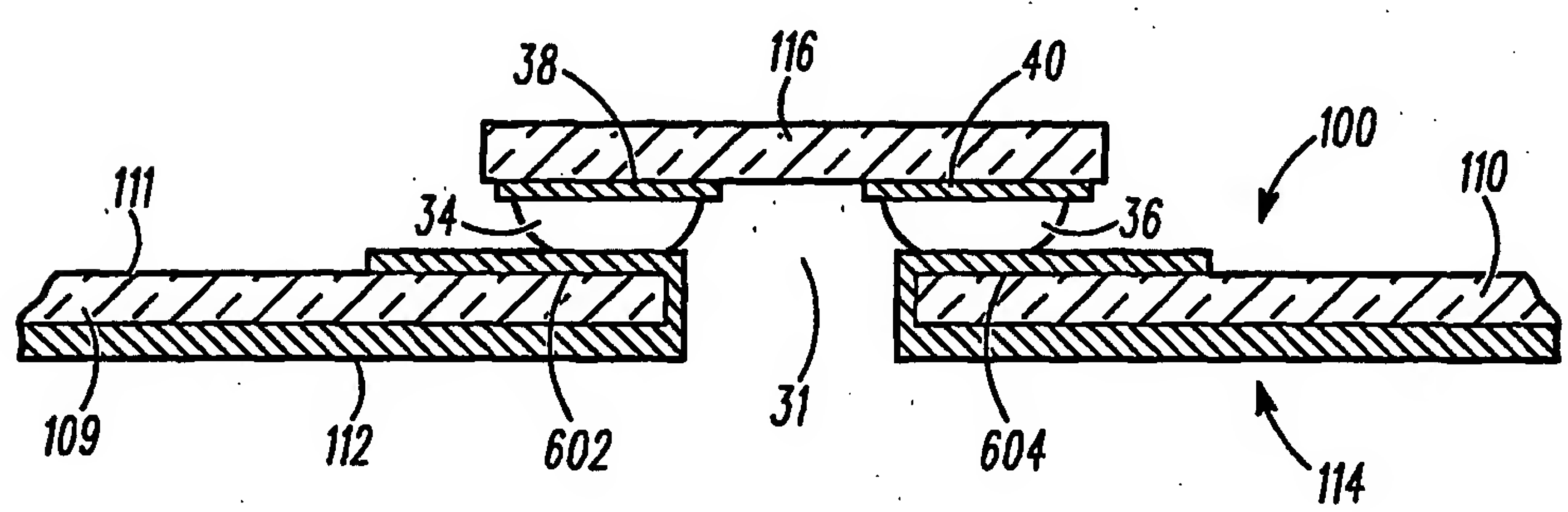

FIG. 9

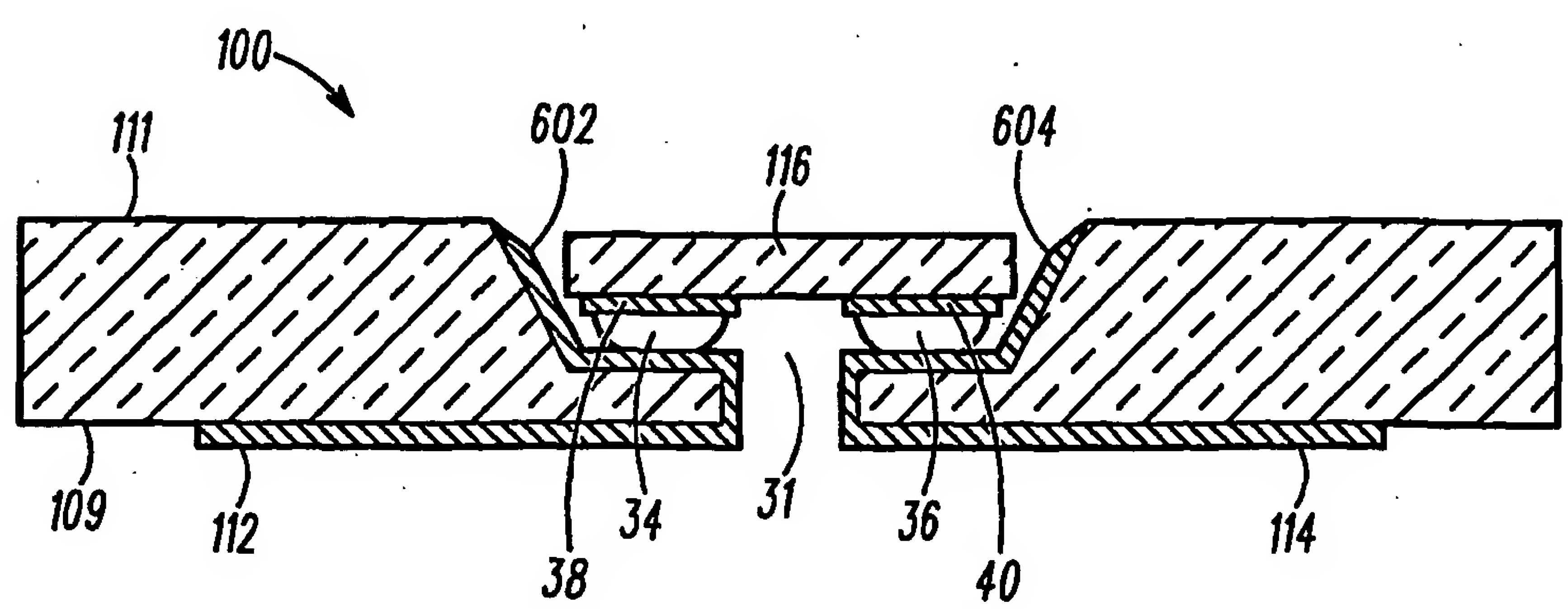

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/18164

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :G08B 13/14
US CL :340/572.1, 572.4, 572.7, 572.8, 568.1, 10.1, 10.3, 10.51
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 340/572.1, 572.4, 572.7, 572.8, 568.1, 10.1, 10.3, 10.51

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 6,147,662 A (GRABAU et al.) 14 November 2000, col. 4, lines 33-36, 55-57 ;col. 5, lines 9-20, 63-67; col. 6, lines 1-14, 46-52; col. 7, lines 62-67; Figs. 4, 5, 7.	1-27,29-34 --------- 28
Y	US 5,742,618 A (LOWE) 21 April 1998, col. 3, lines 1-15; Fig. 1.	28

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 07 SEPTEMBER 2001	Date of mailing of the international search report 10 JAN 2002
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer TOAN N. PHAM Telephone No. (703) 305-4700